METHOD AND SYSTEM FOR USING ZERO-TWISTED YARNS AS FILL YARNS

Cross Reference to Related Application

This application claims priority to, and incorporates by reference in full, the following co-pending application of Applicant: U.S. Provisional Patent Application No. 60/406,996, filed August 29, 2002, entitled "Method and System for Using Zero-Twisted Yarns as Fill Yarns."

Field of the Invention

The present invention relates generally to fill yarns for use in weaving operations, and, in particular, to methods and systems for using yarns with substantially no twist as fill yarns in weaving operations.

Background of the Invention

Glass fibers are produced by flowing molten glass via gravity through a multitude of small openings in a precious metal device, called a bushing. Typical formulations of glass fibers are disclosed in K. Loewenstein, *The Manufacturing Technology of Continuous Glass Fibres*, (3d Ed. 1993).

After the fibers have cooled very shortly after their issuance from the bushing and usually in close proximity to the bushing, these fibers are treated with a chemical treating formulation usually referred to in the art as a sizing composition, sizing, size, binder composition, or binder. The sizing serves to make the fibers more compatible with the

material they will ultimately be used to reinforce and/or to make the fibers easier to process. The sizing can be applied by sprayers, rollers, belts, metering devices, or other similar application devices. The sized glass fibers are gathered into bundles or strands comprising a plurality of individual fibers, generally from 200 to more than 4000. The sized glass fibers generally can have between 0.01 and 5 percent of sizing composition based on the weight of the glass fiber.

After their formation and treatment, the strands can be wound into a spool or "forming package." The strands can be wound onto a tube, for example, using a winder. The forming packages are usually dried in either an oven or at room temperature to remove some of the moisture from the fibers.

Fiber glass strands can be used in a number of ways. For example, fiber glass strands can be included as a warp strand or a weft strand in a woven fabric. In conventional weaving applications, the strands are twisted into a yarn or bulked prior to weaving. In some conventional processes, a strand is fed from a forming package through a twist frame, where a twist is imparted to the strand, and the twisted strand is wound on a bobbin. Among other aspects of some twist frames, the strand can be passed through a traveler or traverse having an eye, the traveler being slidably engaged with a ring which is reciprocated along a central axis of rotation of the bobbin as the strand is wound around the bobbin. The twist is expressed in units of turns of twist per inch or meter. The amount of twist imparted to a strand is typically from about 0.7 to about 3 turns per inch. Factors, such as, for example, the feed rate of the strand to the twisting device, the speed at which the bobbin rotates, and the speed at which the traveler circles the bobbin on the ring, contribute to the amount of twist imparted to the strand.

The twisted strands can then be used to prepare woven fabrics. In a conventional weaving process, the twisted yarns on bobbins are made into warp beams, which provide the yarns for the warp supplies for fabric. Twisted bobbin yarns are also fed to the loom as fill yarns to make the fabric. Fabric can be woven, for example, using a conventional loom, such as a shuttle loom, air jet loom, rapier loom, or other weaving machine. Woven fabrics can be used, for example, in printed circuit board applications.

A major step in fabric preparation is the twisting of the fiber glass strands and the winding of the twisted strands onto bobbins using twist frames. It would be desirable to eliminate the twisting step, particularly the twisting of fiber glass strands that are to be used as fill yarns in a weaving process. It would also be desirable to use forming packages with untwisted fiber glass strands as fill yarns in a weaving process. It would also be desirable to use forming packages as fill yarns by paying out the forming packages from the outside.

Summary

In accordance with the present invention, there are provided methods and apparatuses for weaving fabrics using yarns with substantially no twist as fill yarns. The present invention advantageously provides methods and apparatuses for weaving fabrics using forming packages without a subsequent twisting step. Also provided are woven fabrics comprising fill yarns with substantially no twist, printed circuit boards formed from the woven fabrics, and related products.

The present advantageously facilitates the use of forming packages as fill yarns in weaving processes. As used herein, the term “forming package” refers to a package wound on a winder after formation of the fiber glass and after treatment of the fiber glass with a

sizing composition. Forming packages can be processed and repackaged (e.g., wound into a different, non-forming package) prior to shipment by a fiber glass manufacturer. For example, forming packages can be supplied to a twist frame, where the strands from the forming packages may be twisted and wound into bobbins. A forming package typically has at least strand wound thereon, with each strand comprising a plurality of filaments. Typical forming packages are generally cylindrically-shaped and have a hollow center.

The terms "fill yarn" and "weft yarn" are synonymous and are used interchangeably throughout this application. The term "yarn" is used herein as it is understood to those of skill in the art and can comprise a single strand of twisted or untwisted, multi-filament fiber glass.

An embodiment of a method of weaving a fabric using fill yarns from at least one forming package comprises providing a plurality of warp yarns to a loom, providing at least one forming package of yarn as a fill yarn to the loom by paying out the yarn from the outside of the at least one forming package, and weaving the plurality of warp yarns and the fill yarn to form a fabric. The at least one forming package can comprise a yarn with substantially no twist. In another embodiment, methods of the present invention may not comprise twisting the fill yarn using a twist frame prior to providing the at least one forming package as a fill yarn to the loom. In non-limiting embodiments of the present invention, the plurality of warp yarns may comprise a beam of warp yarns. The plurality of warp yarns may comprise, in another embodiment, a plurality of twisted warp yarns.

Embodiments of the present invention also relate to apparatuses for providing a forming package of yarn with substantially no twist to a loom. One non-limiting embodiment of the present invention comprises at least one package holder and at least one

payout ring removably coupled to the at least one package holder, the payout ring comprising a ring and a hub, wherein the hub secures the payout ring to the package holder.

Embodiments of the present invention also relate to apparatuses for providing a forming package of yarn with substantially no twist to a loom that comprise at least one package holder and at least one payout ring removably coupled to the at least one package holder, the payout ring having a diameter larger than a diameter of the forming package to be provided to the loom. In further embodiments, a payout ring may comprise a ring and a hub, wherein the hub secures the payout ring to the package holder.

In non-limiting embodiments of the present invention, a plurality of spokes may connect the ring to the hub. The at least one package holder, in non-limiting embodiments, may be coupled to a stand and may be configured to hold a forming package.

In some embodiments, the at least one package holder may be substantially horizontally oriented. The at least one package holder may be substantially vertically oriented in other embodiments. The package holder, in other embodiments, may be oriented in positions other than horizontal and vertical configurations.

An apparatus, according to some non-limiting embodiments of the present invention, may comprise a second package holder and a second payout ring removably coupled to the second package holder. The second package holder may be oriented in the same general way as the first package holder in some embodiments (e.g., both are generally horizontal or both are generally vertical), while in other embodiments, the two package holders may be oriented in different general directions.

Embodiments of apparatuses of the present invention may further comprise a guide eyelet. A guide eyelet, in some embodiments, may be associated with a particular package

holder and may assist in providing yarn from a package holder to a loom. Guide eyelets can be particularly useful with package holders that are substantially vertically oriented.

The present invention also relates to systems for weaving fabrics. An embodiment of a system of the present invention can comprise a loom, a beam of warp yarn, at least one package holder, at least one forming package positioned on the at least one package holder, at least one payout ring removably coupled to the at least one package holder. The at least one payout ring can have a diameter larger than the diameter of the at least one forming package. The at least one package holder can be coupled to a stand.

In one embodiment, the at least one payout ring comprises a ring, a hub, and a plurality of spokes connecting the ring to the hub. The hub, in some embodiments, secures the payout ring to the package holder.

The system, in some non-limiting embodiments, may comprise a second package holder, a second forming package positioned on the second package holder, and a second payout ring removably coupled to the second package holder. The second payout ring can have a diameter larger than the diameter of the second forming package.

The at least one package holder can be oriented in a number of ways, including in a substantially horizontal direction, in a substantially vertical direction, and any number of other directions that may facilitate supplying yarn from the at least one package holder to the loom.

Embodiments of the present invention may further comprise at least one guide eyelet. For example, in some embodiments, a guide eyelet may be associated with each package holder. The at least one guide eyelet, in some embodiments, is adapted to assist in providing yarn from at least one of the forming packages to the loom.

These and other embodiments of the present invention are described in greater detail in the detailed description of the invention which follows.

Brief Summary of the Figures

FIG. 1 is a perspective view of a non-limiting embodiment of an apparatus for supplying yarns with substantially no twist to a loom as fill yarns.

FIG. 2 is a perspective view of a non-limiting embodiment of an apparatus for supplying yarns with substantially no twist to a loom as fill yarns.

FIG. 3 is a perspective view of a non-limiting embodiment of an apparatus for supplying yarns with substantially no twist to a loom as fill yarns.

FIG. 4 is a schematic illustrating a non-limiting embodiment of a system of the present invention for weaving fabrics.

FIG. 5 is a perspective view illustrating one way in which a payout ring can be secured to a package holder in an embodiment of an apparatus of the present invention

Detailed Description of the Invention

For the purposes of this specification, unless otherwise indicated, all numbers expressing quantities of ingredients, reaction conditions, and so forth used in the specification are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification are approximations that can vary depending upon the desired properties sought to be obtained by the present invention. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each

numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques.

Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements. Moreover, all ranges disclosed herein are to be understood to encompass any and all subranges subsumed therein. For example, a stated range of "1 to 10" should be considered to include any and all subranges between (and inclusive of) the minimum value of 1 and the maximum value of 10; that is, all subranges beginning with a minimum value of 1 or more, e.g. 1 to 6.1, and ending with a maximum value of 10 or less, e.g., 5.5 to 10. Additionally, any reference referred to as being "incorporated herein" is to be understood as being incorporated in its entirety.

It is further noted that, as used in this specification, the singular forms "a," "an," and "the" include plural referents unless expressly and unequivocally limited to one referent.

The present invention is generally useful in the weaving of fabrics from textile ends, yarns or the like of natural, man-made or synthetic materials. Non-limiting examples of such natural fibers include cotton fibers; man-made fibers include cellulosic fibers such as rayon and graphite fibers; and synthetic fibers including polyester fibers, polyolefin fibers such as polyethylene or polypropylene, and polyamide fibers such as nylon and aromatic polyamide fibers (an example of which is Kevlar™, which is commercially available from E. I. Dupont de Nemours Co. of Wilmington, Del.).

The present invention will be discussed generally in the context of its use in the production, assembly, and application of glass fibers. The present invention may be particularly suited for fiber glass since conventional fiber glass weaving operations involve the twisting of strands from forming packages and the winding of the twisted strands onto bobbins.

Embodiments of the present invention relate generally to methods and apparatuses for weaving fabrics using yarns with substantially no twist as fill yarns. For example, embodiments of the present invention relate to methods and apparatuses for weaving packages using forming packages as fill yarns in which at least one forming package may be paid out from the outside of the package. Also provided in embodiments of the present invention are woven fabrics comprising fill yarns with substantially no twist, printed circuit boards formed from the woven fabrics, and related products.

In one non-limiting embodiment of the present invention, there is provided a method of weaving a fabric using a plurality of yarns with substantially no twist as fill yarns. As used herein, the terms "yarns with substantially no twist" and "zero-twisted yarns" refer to yarns that have not been twisted after being wound on a forming package. For example, "yarns with substantially no twist" have not been twisted using devices such as twisting frames. It should be noted that there is some twist in a fiber glass strand in a forming package that results when fiber glass strands are formed and wound into a forming package. In addition, there can be additional "incidental twist" in the fiber glass strand as it is paid out from the forming package and fed to the loom. Thus, "yarns with substantially no twist" can have some twist in them due to formation and winding and/or due to pay out from the forming package.

The amount of incidental twist in the fiber glass strand due to forming and winding into forming packages and/or pay out from a forming package can be quite smaller than the amount of twist intentionally imparted to fiber glass strands. For example, fiber glass strands from forming packages may be twisted using twist frames with the amount of twist imparted ranging from 0.3 turns of twist per inch to more than five turns of twist per inch.

Accordingly, "yarns with substantially no twist" and "zero-twisted yarns" comprise fiber glass strands having less twist than fiber glass strands that have been twisted on a twist frame. In one embodiment, yarns with substantially no twist comprise fiber glass strands having less than about 0.3 turns of twist per inch. Yarns with substantially no twist may further comprise fiber glass strands having less than about 0.1 turns of twist per inch. In other embodiments, yarns with substantially no twist may have less than about six turns of twist per yard. In further embodiments, yarns with substantially no twist may have less than about three turns of twist per yard.

"Yarns with substantially no twist" and "zero-twisted yarns" can comprise yarns that are supplied to a weaving device directly from a forming package. As noted above, the term "forming package" refers to the assemblage of at least one strand on a winder after formation of the strand in a fiber forming apparatus. For embodiments of the present invention, the forming package can typically have one strand.

Among other features, the present invention provides for the outside payout of forming packages to be supplied as fill yarns to a loom. Outside payout of forming packages, in accordance with embodiments of the present invention, can reduce strand friction between the strand as it is removed from the forming package and the forming package itself. Outside payout of forming packages utilizing embodiments of the present

invention can also be desirable over inside payout of forming packages due to the possibility of a package collapsing when enough of the interior of the forming package is removed during inside payout. Outside payout of forming packages can also enable more fiber glass to be supplied to a loom than inside payout for similar reasons.

Embodiments of the present invention relate to methods of weaving fabrics using fill yarns from at least one forming package. In one embodiment, a method comprises providing a plurality of warp yarns to a loom, providing at least one forming package of yarn as a fill yarn to the loom by paying out the yarn from the outside of the at least one forming package, and weaving the plurality of warp yarns and the fill yarn to form a fabric. The at least one forming package can comprise a yarn with substantially no twist. In another embodiment, methods of the present invention may not comprise twisting the fill yarn using a twist frame prior to providing the at least one forming package as a fill yarn to the loom.

Embodiments of the present invention also relate to apparatuses for providing a forming package of yarn with substantially no twist to a loom. One non-limiting embodiment of the present invention comprises at least one package holder and at least one payout ring removably coupled to the at least one package holder, the payout ring comprising a ring and a hub, wherein the hub secures the payout ring to the package holder.

Non-limiting embodiments of the present invention also relate to apparatuses for providing a forming package of yarn with substantially no twist to a loom that comprise at least one package holder and at least one payout ring removably coupled to the at least one package holder, the payout ring having a diameter larger than a diameter of the forming package to be provided to the loom. In further embodiments, a payout ring may comprise a ring and a hub, wherein the hub secures the payout ring to the package holder.

In some embodiments, the at least one package holder may be substantially horizontally oriented. The at least one package holder may be substantially vertically oriented in other embodiments. The package holder, in other embodiments, may be oriented in positions other than horizontal and vertical configurations. For example, in other embodiments, the package holder may be angled toward the loom. The orientation of the package holder may be selected based on a number of factors including angle of the yarn upon delivery from the forming package to the loom, ease of loading forming packages onto apparatus, number of forming packages to be supplied to loom, and others.

An apparatus, according to some non-limiting embodiments of the present invention, may comprise a second package holder and a second payout ring removably coupled to the second package holder. Other embodiments of apparatuses of the present invention may comprise more than two package holders. In embodiments utilizing a second package holder, the second package holder may be oriented in the same general way as the first package holder in some embodiments (e.g., both are generally horizontal or both are generally vertical), while in other embodiments, the two package holders may be oriented in different general directions (e.g., one substantially horizontal and one substantially vertical). As noted above, the package holders may be oriented in a number of directions other than substantially horizontal and substantially vertical.

Embodiments of apparatuses of the present invention may further comprise a guide eyelet. A guide eyelet can be an optional feature depending on the orientation of the package holders. For example, a guide eyelet may not be necessary when the forming packages are to be oriented generally horizontally. In some embodiments, a guide eyelet may be provided for each package holder, such that two guide eyelets may be provided for apparatuses

utilizing two package holders. A guide eyelet, in some embodiments, may be associated with a particular package holder and may assist in providing yarn from a package holder to a loom. Guide eyelets can be particularly useful with package holders that are substantially vertically oriented.

The present invention also relates to systems for weaving fabrics. A non-limiting embodiment of a system of the present invention can comprise a loom, a beam of warp yarn, at least one package holder, at least one forming package positioned on the at least one package holder, at least one payout ring removably coupled to the at least one package holder. The at least one payout ring can have a diameter larger than the diameter of the at least one forming package. The at least one package holder can be coupled to a stand. In one embodiment, the at least one payout ring comprises a ring, a hub, and a plurality of spokes connecting the ring to the hub. The hub, in some embodiments, secures the payout ring to the package holder.

The system, in some non-limiting embodiments, may comprise a second package holder, a second forming package positioned on the second package holder, and a second payout ring removably coupled to the second package holder. The second payout ring can have a diameter larger than the diameter of the second forming package.

Persons of ordinary skill in the art will recognize that the present invention can utilize a variety of glass fibers that are useful in weaving applications as either warp yarns or fill yarns. Non-limiting examples of glass fibers suitable for use in the present invention can generally include any glass fiber that has been used in weaving applications, although the glass composition should not be viewed as limiting in this invention. For fabrics to be used

in electronics applications, such glass fibers can include, for example, those prepared from fiberizable glass compositions such as “D-glass”, “E-glass”, “DE-glass”, and “G-glass.”

The glass fiber strands used as warp yarns or fill yarns in the present invention can be formed using any suitable method known in the art for forming glass fibers. For example, glass fibers can be formed in a direct-melt fiber forming operation or in an indirect, or marble-melt, fiber forming operation. In a direct-melt fiber forming operation, raw materials are combined, melted, and homogenized in a glass melting furnace. The molten glass moves from the furnace to a forehearth and into fiber forming apparatuses where the molten glass is attenuated into continuous glass fibers. In a marble-melt glass forming operation, pieces or marbles of glass having the final desired glass composition are preformed and fed into a bushing where they are melted and attenuated into continuous glass fibers. If a premelter is used, the marbles are fed first into the premelter, melted, and then the melted glass is fed into a fiber forming apparatus where the glass is attenuated to form continuous fibers. In the present invention, the glass fibers can be formed by the direct-melt fiber forming operation. For additional information relating to glass compositions and methods of forming the glass fibers, see K. Loewenstein, *The Manufacturing Technology of Continuous Glass Fibres*, (3d Ed. 1993), at pages 30-44, 47-103, and 115-165, which are specifically incorporated by reference herein.

Immediately after formation, the filaments are at least partially coated with a binder composition. The application of binder compositions to glass fibers is well known in the art and can be accomplished by conventional methods such as a belt applicator, a "kiss-roll" applicator, or by spraying. Binder compositions known to those of ordinary skill in the art that are normally used to coat glass fibers for use as either warp yarns or fill yarns in

weaving applications can be used in the present invention. Such binders include, for example, starch/oil-based binders.

The glass fibers are then gathered into at least one strand, and collected into a forming package on a winder. See generally K. Loewenstein, *The Manufacturing Technology of Continuous Glass Fibres*, (3d Ed. 1993). The strands are, in some non-limiting embodiments, wound onto tubes to form forming packages. The diameter of the paper tube is a function of the diameter of the winder's collet. The thickness of the tube can be selected, for example, based on the size and type of fiber glass being formed, the desired size of the forming package, the desired use of the forming package, and other factors. In non-limiting embodiments, the tubes can be constructed from collapsible, frangible materials, such as paper. These embodiments can utilize such materials as the tubes may only be used for winding and may not be used for long term storage and transport. However, in other embodiments, more durable tubes may be used to wind forming packages, particularly if the forming packages are to be shipped to another location.

The forming packages are then dried. The forming packages can be dried using a conventional hot air oven, a Vacudyne oven, a dielectric oven or other techniques known to be useful in drying forming packages. For example, the drying temperatures can be between 190° F and 250° F, and the drying time can be in the range of nine to twenty-four hours.

The fiber glass strands that are to be used as warp yarns can then be twisted in non-limiting embodiments of the present invention. Although warp yarns are twisted in the embodiment discussed below, other embodiments of the present invention may utilize yarns with substantially no twist or zero-twisted yarns as warp yarns. In embodiments where the warp yarns are to be twisted, forming packages with strands that are to be used as warp yarns

can be positioned on twist frames, where the strands are twisted and wound into bobbins. Examples of twist frames suitable for twisting fiber glass strands in non-limiting embodiments of the present are commercially available from: Rieter ICBT of Genas, France; BACO Machinery, Inc. of Gastonia, North Carolina; Saco Lowell, Inc. of Greenville, South Carolina; and Elitex Machinery s.r.o. of Kdyne, Czech Republic. Among other aspects of typical twist frames, the strand can be passed through a traveler or traverse having an eye, the traveler being slidably engaged with a ring which is reciprocated along a central axis of rotation of the bobbin as the strand is wound around the bobbin. Typical processes utilizing twist frames impart from about 0.5 turns per inch to more than three turns per inch to a strand.

The twisted strands on the bobbins can then be assembled into warp beams using techniques known to those of ordinary skill in the art. A warp beam supplies the warp yarns to a loom for producing a woven fabric. In further non-limiting embodiments, the fiber glass strands from the bobbins can be "slashed" as the warp beam is being formed to increase the strength of the strands in the beam and to protect the strands against abrasion during the weaving process. A warp beam can be slashed using techniques known to those of ordinary skill, such as treating the warp beam with a poly(vinyl alcohol) solution. In one non-limiting embodiment, twisted strands on the bobbins can be assembled into section beams, and the section beams can then be slashed, dried, and assembled into a warp beam.

In general, beamed warp yarns conventionally used in weaving operations can be used in embodiments of the present invention. Examples of suitable beamed warp yarns are commercially available from PPG Industries, Inc. and can include the following products:

D450/681 1/0, DE150/631 1/0, DE100/690 1/0, DE75/610 1/0, DE37/610 1/0, E225/681 1/0, G150/639 1/0, G150/695 1/0, G75/690 1/0, G75/695 1/0, G50/695 1/0, and G37/690 1/0.

The products listed in the above paragraph and the products listed below are provided using the nomenclature of PPG Industries, which provides information about the product. The letter in these product names indicates the nominal diameter of the filaments forming the strand. The first group of numbers (e.g., “450” in “D450”) represents 1/100 of the total approximate number of yards in a single pound of strand (e.g., 450 = 45,000 yards per pound of strand). This is known as the strand count. The next set of numbers (“1/0”) reveals the number of basic strands in the yarn. The above-listed products are single strand yarns. When more than one strand is used to form the yarn, the second digit, which is separated by the diagonal, indicates the number of strands that have been plied together to form the final product.

In addition to warp yarns, a weaving process also utilizes a fill yarn. In non-limiting embodiments of the present invention, a forming package can directly supply the fill yarn to a loom. In conventional weaving processes, strands from forming packages were typically fed through a twist frame and wound on bobbins, and the twisted yarns on the bobbins were fed to the loom as fill yarns. Strands from a forming package have substantially no twist, as described above. Thus, when strands from a forming package are fed to a loom as a fill yarn, the fill yarn also has substantially no twist. By supplying the fill yarn to a loom from a forming package, the twisting step and the use of twist frames for the production of fill yarns are eliminated.

In general, many fiber glass products that have traditionally been twisted and wound on bobbins may be used as fill yarns in embodiments of the present invention. Rather than

unwinding the forming packages and feeding the strands to a twist frame, the strands from the forming packages may be supplied to a loom. PPG Industries, Inc. produces a number of products currently sold as twisted bobbin yarns that could be used as fill yarns from forming packages (e.g., without twisting and winding on a bobbin). The following products, available as bobbin yarns, are commercially available from or may be made available from PPG Industries, Inc., and could be used as fill yarns from their forming packages without twisting: D450/638 1/0, D450/631 1/0, D450/681 1/0, D450/4551 1/0, DE37/207 1/0, DE37/610X 1/0, DE75/207 1/0, DE75/610 1/0, DE100/610 1/0, DE100/690 1/0, DE100/880 1/0, DE150/631 1/0, DE300/681 1/0, E225/638 1/0, E225/631 1/0, E225/681 1/0, G37/209 1/0, G37/690 1/0, G37/610 1/0, G75/422 1/0, G75/610 1/0, G75/615 1/0, G75/658 1/0, G75/690 1/0, G75/695 1/0, G75/880 1/0, G150/621 1/0, G150/639 1/0, G150/658 1/0, G150/690 1/0, G150/695 1/0, and G150/880 1/0. Other products that may be acceptable as fill yarns include PPG Industries, Inc.'s InnoFiber™ no-twist yarn products, such as 7300 NTY with 2691 binder, and 3700 NTY with 2691 binder.

FIGS. 1-4 illustrate non-limiting embodiments of apparatuses for feeding yarns with substantially no twist to a loom as fill yarns. FIGS. 1 and 2 illustrate a non-limiting embodiment of an apparatus 5 for feeding yarns with substantially no twist to a loom as fill yarns. In the embodiment shown, the apparatus 5 comprises a stand 10, two package holders 12, 14, and payout rings 15, 20 coupled to the package holders 12, 14. In one non-limiting embodiment, the apparatus can be attached to a floor or other surface to prevent it from sliding when fill yarn is fed to the loom.

In FIG. 1, a forming package 25, 30 is positioned on each of the package holders 12, 14. The diameter of the package holder is slightly smaller than the inside diameter of the

forming package's paper tube to allow the forming package to slide onto the package holder. In the embodiment shown in FIG. 2, the package holders 12, 14 comprise frames having a plurality of longitudinal bars 13 that the forming packages can slide over. In other embodiments, the package holders can comprise a hollow cylinder. The package holder can generally be a structure that allows a forming package to be positioned on it.

The payout rings 15, 20 are removably coupled to the package holders 12, 14. The payout rings 15, 20 can be removed to place forming packages 25, 30 on the package holders 12, 14. When forming packages are placed on the package holders, the payout rings 15, 20 can again be coupled to the package holders 12, 14.

The payout rings 15, 20, in one non-limiting embodiment, can be "locked" into position on the end of the package holders in order to prevent the forming packages 25, 30 from being pulled off of the package holders 12, 14 and to prevent the payout rings 15, 20 from rotating as strands are paid out from the forming packages. FIG. 5, discussed below, illustrates one way in which a payout ring can be secured to a package holder.

Although the Figures show two forming packages supplying fill yarns to a loom, only one forming package, in other non-limiting embodiments, can supply fill yarn with substantially no twist to a loom. In other non-limiting embodiments, a plurality of forming packages (e.g., more than two forming packages) supply fill yarn with substantially no twist to a loom. The number of forming packages supplying fill yarn to a loom is dependent, for example, on the type of loom being used and the loom's capacity.

The payout rings 15, 20 assist in feeding the fiber glass strands from the forming packages as fill yarns to the loom. In particular, a payout ring enables a strand to be paid out from the outside of the forming package. As a strand is paid out from the outside of a

forming package, it revolves around the payout ring (e.g., as the package unwinds, it follows the outside of the payout ring). In other non-limiting embodiments, the forming package may be wound without a paper tube, and the strand may be paid out from the inside of the forming package.

The embodiment of a payout ring 15 shown in FIG. 1 includes a ring 35, a hub 40, and a plurality of spokes 45. The diameter of the ring 35, in one non-limiting embodiment, is larger than the diameter of a full forming package (i.e., one that has not been unwound after being removed from a winder). By using a ring with a diameter larger than the forming package, the ring minimizes any abrasion resulting from the pay out of the strand from the forming package. In other words, without a payout ring, the strand could slide over the surface of the forming package as it was paid out, which could increase broken filaments and fuzz and could negatively impact the weaving process and any fabrics produced. In one non-limiting embodiment of the present invention, the diameter of the payout rings is between 0.5 and five inches greater than the diameter of the forming package prior to unwinding.

The payout ring can be constructed from a number of materials including, without limitation, steel, plastic, composite materials, and other materials that generally do not have an abrasive surface. The stand, package holders, and other components of the apparatus can be constructed from any number of suitable materials, including steel, plastic, and composite materials.

The hub 40, among other functions, assists in coupling the payout ring 15 to the package holder as illustrated in FIG. 5. The spokes 45 connect the ring 35 to the hub 40 and provides structural support to the ring 35. The distance between the center of the hub 40 and the plane in which the ring 35 lies (i.e., the height of the cone formed by the hub 40, the

spokes 45, and the plane in which the ring 35 lies) can depend on the payout efficiency and the distance to the loom. In one non-limiting embodiment, this distance is between one inch and six inches. As an alternative to modifying the distance between the center of the hub 40 and the plane in which the ring lies 35, the diameter of the ring 35 can be selected based on the payout efficiency and the distance to the loom. In other non-limiting embodiments, the diameter of the ring 35 and the distance between the center of the hub 40 and the plane in which the ring 35 lies are both selected based on the payout efficiency and the distance to the loom.

In the embodiment shown in FIGS. 1 and 2, the package holders are substantially horizontally oriented. FIG. 3 is a picture illustrating another embodiment of an apparatus 75 for supplying yarns with substantially no twist to a loom as fill yarns in which the package holders 80, 85 are substantially vertically oriented. In the embodiment shown, the apparatus 75 comprises a stand 77, two package holders 80, 85 affixed to the stand 77, and payout rings 90, 95 coupled to the package holders 80, 85. Payout rings 90, 95 are removably coupled to each of the package holders 80, 85. In one non-limiting embodiment, the payout rings 90, 95 can be removably coupled to the package holders 80, 85 in the manner described with regard to FIG. 5. As with the embodiment shown in FIGS. 1 and 2, the payout rings 90, 95 can be removed to place forming packages 100, 105 on the package holders 80, 85. After forming packages are placed on the package holders, the payout rings can again be coupled to the package holder. The payout rings, in one non-limiting embodiment, can be “locked” into position on the end of the package holders (as shown, for example, in FIG. 5) in order to prevent the forming packages from being pulled off of the package holders and to prevent the payout rings from rotating as strands are paid out from the forming packages. In the non-

limiting embodiment shown, a payout ring 80 can comprise a ring 110, a hub 115, and a plurality of spokes 120.

FIG. 4 illustrates a non-limiting embodiment of a system of the present invention for weaving fabrics. In the embodiment shown, the system comprises a loom 125, an apparatus 130 for feeding forming packages of yarn with substantially no twist to the loom 125, and a supply of warp yarn. The supply of warp yarn, in the embodiment shown, is a warp beam 135. The warp yarn can be woven with fill yarn from the apparatus 130 using the loom 125 to form a fabric 140. The loom 125, the warp beam 135, and the woven fabric 140 are represented schematically in FIG. 4.

In FIG. 4, the non-limiting embodiment of an apparatus 130 for feeding forming packages of yarn with substantially no twist to loom 125 includes a stand 145, a substantially horizontally oriented package holder 150 affixed to the stand 145, and a substantially vertically oriented package holder (not visible) affixed to the stand 145. In the embodiment shown, the vertically oriented package holder (not visible) is positioned on a base 162 affixed to the stand 145. Forming packages 155, 160 are positioned on each of the package holders. Payout rings 165, 170 are coupled to the package holders. As shown in FIG. 4, strands 180, 185 are paid out from the outside of the forming packages 155, 160 and are fed to the loom 125 as fill yarns. FIG. 4 illustrates how the payout rings 165, 170 enable strands 180, 185 to be paid out from the outside of the forming packages 155, 160 while minimizing any potential abrasion that might result from the pay out of the strands 180, 185 from the forming packages 155, 160.

In the embodiment shown in FIG. 4, a guide eyelet 190 is affixed to the stand 145. The strand 185 from the substantially vertically oriented forming package 160 is fed through

the guide eyelet 190. The guide eyelet 190 also assists in feeding the strand 185 to the loom 125 while minimizing contact with forming package 160 as the strand 185 is paid out.

As mentioned above, the warp yarns are fed to the loom 125 via the warp beam 135. The fill yarns are fed to the loom 125 from the forming packages 155, 160 using the payout ring/package holder assembly described above. The loom can be, in non-limiting embodiments of the present invention, an air jet loom, a rapier loom, or other weaving apparatuses. Examples of suitable air jet looms and rapier looms for use in non-limiting embodiments of the present are commercially available from: Sulzer Textil Limited of Switzerland; Tsudakoma Corporation of Nomachi, Kanazawa-shi, Japan; and Toyota Industries Corporation of Kariya-shi, Aichi, Japan.

As noted above, payout rings can be removably secured to package holders in a number of ways. FIG. 5 illustrates one way in which a payout ring can be secured to a package holder in a non-limiting embodiment of an apparatus of the present invention. FIG. 5 shows a payout ring 220 that includes a ring 225, a hub 230, and a plurality of spokes 235. The hub 230, in the embodiment shown, includes a reduced diameter portion 237 that facilitates the connection of the payout ring 220 to the package holder. Two pins 240 extend from the outer surface of the reduced diameter portion of the hub 237. In other embodiments, a single pin can extend through the hub. A package holder 245 is also shown in a cutaway view in FIG. 5. The package holder 245 shown comprises a hollow cylinder 250 and an end piece 255. The end piece 255 includes a keyhole 260 for receiving the hub 230 of the payout ring 220. The keyhole 260 is shaped such that the hub 230 and the two pins 240 of the payout ring 220 can slide into it. After the hub 230 is inserted a certain distance into the keyhole 260, the payout ring 220 can be rotated in order to "lock" the

payout ring 220 and prevent it from being pulled off of the package holder 245. In other words, at a predetermined distance, the pins 240 are able to rotate in the end piece 255 without allowing the hub 230 to be pulled out of the keyhole 260. To remove the payout ring 220 from the package holder 245, the payout ring 220 can be rotated until the pins 240 align with the keyhole 260, which allows the payout ring 220 to be removed.

The present invention also relates to fabrics and a number of other products that may be formed using methods and apparatuses of the present invention. A fabric of the present invention can comprise a plurality of warp yarns and at least one fill yarn with substantially no twist. Fabrics of the present invention, in one non-limiting embodiment, can have a number of improved properties over fabrics woven with twisted fill yarns. For example, when yarn with substantially no twist is used as a fill yarn in a fabric, the fabric may have slightly higher density and slightly lower air permeation.

The present invention also relates to prepregs for electronic circuit boards. In one non-limiting embodiment, a prepreg for electronic circuit boards can comprise a resin and at least one fabric comprising a plurality of warp yarns and at least one fill yarn with substantially no twist. Any number of resins known to those skilled in the art can be used to form prepregs of the present invention. Resins useful in embodiments of the present invention can include, by way of non-limiting examples, phenolic resin systems, epoxy resin systems, polyester resin systems, polytetrafluoroethylene (PTFE) resin systems, and polystyrene systems. Prepregs utilizing such fabrics may have improved resin "wet-out" and "wet-through." As used herein, the term "wet-out" refers to penetration of a resin through the individual bundles or strands of fibers in the mat or fabric. As used herein, the term "wet-through" refers to the penetration of a resin through the mat or fabric.

Other non-limiting embodiments of the present invention relate to methods of forming laminates for use in electronic support applications. A non-limiting embodiment of such a method can comprise obtaining a fabric adapted to reinforce an electronic support formed by weaving at least one fill yarn with substantially no twist and at least one warp yarn, at least partially coating at least a portion of the fabric with a resin, at least partially curing the at least partially coated fabric to form a prepreg layer, and laminating two or more prepreg layers together to form a laminate adapted for use in the electronic support. Any number of resins known to those skilled in the art can be used to form prepregs of the present invention. Resins useful in embodiments of the present invention can include, by way of non-limiting examples, phenolic resin systems, epoxy resin systems, polyester resin systems, polytetrafluoroethylene (PTFE) resin systems, and polystyrene systems. The fabric can be at least partially coated with the resin, the at least partially coated fabric can be cured, and the two or more prepregs can be laminated using techniques known to those of ordinary skill in the art.

The present invention also relates to methods of forming electronic supports. In one non-limiting embodiment, a method of forming an electronic support can comprise obtaining a fabric adapted to reinforce an electronic support formed by weaving at least one fill yarn with substantially no twist and at least one warp yarn, at least partially coating at least a portion of the fabric with a resin, at least partially curing the coating into the at least a portion of the fabric to form a prepreg layer; and laminating one or more prepreg layers together with one or more electrically conductive layers to form the electronic support.

An additional non-limiting embodiment of the present invention relates to an electronic circuit board, which can comprise (a) an electronic support comprising (i) at least

one fabric fabric formed by weaving at least one fill yarn with substantially no twist and at least one warp yarn; and (ii) at least one resin on at least a portion of the at least one fabric in the electronic support; and (b) an electronically conductive layer, the support and the conductive layer being contained in the electronic circuit board. Non-limiting embodiments of the printed circuit board can be formed from fabrics of the present invention using techniques known to those of ordinary skill in the art.

Desirable characteristics, which can be exhibited by the present invention, include, but are not limited to the provision of: methods of weaving fabrics using forming packages as fill yarns; apparatuses for feeding forming packages as fill yarns to a loom; methods for paying out forming packages from the outside; apparatuses for paying out forming packages from the outside; methods and apparatuses of weaving fabrics using forming packages as fill yarns by paying out the forming packages from the outside; systems for weaving fabrics from warp yarns and from fill yarns with substantially no twist; methods of weaving fabrics that eliminate the twisting of fill yarns prior to weaving; fabrics having desirable properties formed from warp yarns and from fill yarns with substantially no twist; laminates, electronic support materials, and printed circuit boards having desirable properties formed from fabrics comprising warp yarns and fill yarns with substantially no twist; a process for weaving fabrics with a reduction in variable costs; and systems and methods for producing fabrics that require fewer twist frames.

Various embodiments of the invention have been described in fulfillment of the various objects of the invention. It should be recognized that these embodiments are merely illustrative of the principles of the present invention. Numerous modifications and

adaptations thereof will be readily apparent to those skilled in the art without departing from the spirit and scope of the present invention.

What is claimed is: